MARS SAMPLE RETURN: THE NEXT STEP REQUIRED TO REVOLUTIONIZE KNOWLEDGE OF MARTIAN GEOLOGICAL AND CLIMATOLOGICAL HISTORY

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The capability of scientific instrumentation flown on planetary orbiters and landers has made great advances since the signature Viking mission of the seventies. At some point, however, the science return from orbital remote sensing, and even *in situ* measurements, becomes incremental, rather than revolutionary. This is primarily caused by the low spatial resolution of such measurements, even for landed instrumentation, the incomplete mineralogical record derived from such measurements, the inability to do the detailed textural, mineralogical and compositional characterization needed to demonstrate equilibrium or reaction paths, and the lack of chronological characterization. For the foreseeable future, flight instruments will suffer from this limitation. In order to make the next revolutionary breakthrough in understanding the early geological and climatological history of Mars, samples must be available for interrogation using the full panoply of laboratory-housed analytical instrumentation.

Laboratory studies of samples allow for determination of parageneses of rocks through microscopic identification of mineral assemblages, evaluation of equilibrium through electron microbeam analyses of mineral compositions and structures, determination of formation temperatures through secondary ion or thermal ionization mass spectrometry (SIMS or TIMS) analyses of stable isotope compositions. Such details are poorly constrained by orbital data (*e.g.* phyllosilicate formation at Mawrth Vallis [1]), and incompletely described by *in situ* measurements (*e.g.* genesis of Burns formation sediments at Meridiani Planum [2]). Laboratory studies can determine formation, metamorphism and/or alteration ages of samples through SIMS or TIMS of radiogenic isotope systems; a capability well-beyond flight instrumentation.

Ideally, sample return should be from a location first scouted by landers such that fairly mature hypotheses have been formulated that can be tested [3]. However, samples from clastic sediments derived from an extensive region of Mars can provide important, detailed understanding of early martian geological and climtological history. Interrogating clastic “sediments” from the Earth [4, 5], Moon [6] and asteroids [7] has allowed discovery of new crustal units, identification of now-vanished crust, and determination of the geological history of extensive, remote regions. Returned sample of martian fluvial and/or aeolian sediments, for example from Gale crater, could be “read like a book” in terrestrial laboratories to provide truly revolutionary new insights into early martian geological and climatological evolution.

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